storing a posture of the at least one first object at least at points at which the at least one first object has a posture wherein a portion of at least one geometric region penetrates the at least one static object; and

determining the posture being stored based on at least one of a niceness factor associated with the one or more geometric regions penetrating the at least one static object, and a depth of the penetration of the one or more geometric regions.

REMARKS

In response to the Office Action mailed October 3, 2002, Applicant respectfully requests reconsideration. Claims 1-2, 4-8, 10-27, 29-33 and 35-66 have been previously examined. By this Amendment, claims 1, 26, 35, 36 and 43 are amended and claims 4 and 29 are canceled. Accordingly, claims 1-2, 5-8, 10-27, 30-33 and 35-66 are pending in this application, of which claims 1, 10, 26, 35, 43, 47, 52 and 62 are independent claims. The application as presented is believed to be in allowable condition.

I.   Final Rejection Premature

The Office Action asserts finality under MPEP § 706.07(a) which states *inter alia*:

> Under present practice, second or any subsequent actions on the merits shall be
> final, except where the examiner introduces a new ground of rejection that is
> neither necessitated by applicant's amendment of the claims nor based on
> information submitted in an information disclosure statement filed during the
> period set forth in 37 CFR 1.97(c) with the fee set for in 37 CFR 1.17(p).

The Examiner asserts that Applicant's amendments to the claims in response to the previous Office Action (mailed on January 15, 2002) necessitated the introduction of the new ground for rejection set forth in the present Office Action. Applicant respectfully disagrees. The above statement in the MPEP describes the circumstance where, but for Applicant's amendments, no new ground of rejection would be necessary. However, Applicants amendments did not necessitate the new grounds for rejection as established by the MPEP. In particular, independent claim 10 was not amended in the response to the previous Office Action. The MPEP explicitly

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addresses this precise situation and declares that it shall be a <u>bar</u> to asserting finality. Specifically, in the same section of the MPEP cited in the Office Action and in the foregoing (§ 706.07(a)), the MPEP states:

> Furthermore, a second or any subsequent action on the merits in any application or patent undergoing reexamination proceedings will <u>not</u> be made final if it includes a rejection, on newly cited art, ... <u>of any claim not amended by applicant</u> or patent owner <u>in spite of the fact that other claims may have been amended to require newly cited art</u>. (emphasis added).

Therefore, despite having amended some claims in the previous response, the present Office Action is barred from asserting finality because the Office Action includes a rejection on "newly cited art" (Shih et. al.) of a "claim not amended by the applicant" (independent claim 10). As such, the finality of the Office Action is therefore improper and Applicant respectfully requests that finality be withdrawn.

II.   Rejections Under 35 U.S.C. § 102

The Office Action rejects claim 1, 2, 4-8, 10-27, 29-33 and 35-66 under 35 U.S.C. § 102(e) as being anticipated by Shih et al. (U.S. Patent No. 6,421,048). Applicant respectfully traverses this rejection.

The Office Action sets forth an omnibus rejection citing various teachings of the Shih reference that allegedly anticipate the subject matter in each of Applicant's independent claims. However, the Office Action fails to indicate which teachings are believed to meet which limitations of the claims. As a general matter, Applicant notes that numerous concepts-conceived and implemented by Applicant are nowhere disclosed or suggested by Shih.

In particular, Shih is completely silent with respect to various representational techniques recited in the claims including binary space partition trees and bounding volume hierarchies. In addition, Shih nowhere discloses or suggests concepts related to generating and utilizing posture maps, the use of guide zones, snap fit regions or niceness factors. Applicant specifically addresses these issues in connection with the independent claims below.

A.   Claims 1 and 26

Claims 1 and 26 have been amended to include subject matter recited in canceled claims 4 and 29, respectively. In the rejection of claims 4, 18, 29 and 37-38, the Office Action asserts that the binary space partition tree representations recited in the claims are anticipated since "Shih teaches a way to locate the virtual surface (25) in terms of binary search." However, this is an incorrect comparison of two different concepts. Performing a binary search and representing a virtual object with a binary space partition tree simply are not the same or equivalent.

In particular, Shih locates a point near a virtual surface by performing a binary search along a line connecting two points. In contrast, the present Application employs a binary space partition tree in the representation of a virtual object. A binary space partition tree is a particular and specific structure for spatially grouping and storing an object representation organized and arranged as a binary tree (e.g., having a root node, branches and leaves, etc.). In contrast, a binary search is not an object representation, does not spatially arrange or group either the representation of virtual object 26 or virtual surface 25 and simply is not a binary space partition tree as incorrectly asserted in the Office Action.

Claim 1, as amended, recites a method for controlling the simulated interfacing of a first body controlled by a user with a second body, while providing haptic feedback to the user on such interfacing. The method includes storing selected representations of said first body and of said second body in a processing apparatus, the representation for one of said bodies including an implicit representation and a binary space partition tree and the representation for the other body being a discrete representation, using a user controlled interface device to control simulated movement of the first body relative to the second body, detecting any collision between the first body and the second body, including the position on each body of each collision, the direction of the collision, and force for the collision, converting the detected direction, point and force for each collision into at least one force vector on the first body, and applying said at least one force vector as a corresponding feedback force vector to said interface device, and thus to the user.

Shih does not disclose or suggest representing a body in a simulated interfacing wherein the body includes "an implicit representation and a binary space partition tree," as recited in claim 1. Therefore, claim 1 patentably distinguishes over Shih and is in allowable condition.

Claims 2 and 5-8 depend from and further limit claim 1 and are allowable for at least the same reasons.

Claim 26, as amended, recites a system for controlling the simulated interfacing of a first body controlled by a user with a second body, while providing haptic feedback to the user on such interface. The system includes at least one memory storing selected representations of said first body and of said second body, the representation for one of said bodies including an implicit representation and a binary space partition tree and the representation for the other body being a discrete representation, a user controlled hepatic interface device, and processing apparatus responsive to said interface device for providing simulated movement of the first body relative to the second body, said processing apparatus detecting collisions between the bodies resulting from such simulated movement, including the position on each body of each collision, the direction of the collision, and force for the collision, converting the detected direction, point and force for each collision into at least one force vector and, feeding back the at least one force vector through said interface device.

Shih nowhere discloses or suggests a system for controlling the simulated interfacing of a first body controlled by a user with a second body, storing representations of the first and second bodies, "the representation for one of said bodies including an implicit representation and a binary space partition tree," as recited in claim 26. Therefore, claim 26 patentably distinguishes over Shih and is in allowable condition.

Claims 27 and 30-33 depend from and further limit claim 26 and are allowable for at least the same reasons.

B.   Claim 35

The Office Action seems to assert that since "Shih teaches the virtual object (26) being implemented as a volume of voxels (78) and the volume storing a density value and a density threshold respectively," the representation of an object including a point cloud and a bounding volume hierarchy representation is anticipated. However, the Office Action is referring to various teachings of Shih that share no similarity with the subject matter of Applicant's claims. A voxel representation is simply not equivalent to a bounding volume hierarchy. Rather, they are two very different concepts.

Specifically, a voxel is a three dimensional pixel, that is, a volume having assigned to it a scalar value. In Shih, that scalar value represents "density." In contrast, a bounding volume hierarchy is a specific spatial structure enclosing an underlying representation. In particular, a bounding volume hierarchy is a progressively refined organization of bounding volumes approximating an underlying representation from a coarse to a fine approximation. The organization is often stored as a tree structure or in a similar hierarchical relationship such that bounding volumes appearing higher in the hierarchy enclose a superset of the space enclosed by volumes so related and appearing lower in the hierarchy. Such a structure is simply nowhere to be found in the Shih reference and is completely dissimilar to the voxel representation described in Shih.

Claim 35, as amended, recited a method of providing haptic feedback corresponding to full-body contact between a first object controlled by an interface device and at least one second object. The method comprises acts of storing a first three dimensional representation and a second three dimensional representation of the first object and the at least one second objects, respectively, wherein one of the representations includes at least one region defined by a implicit equation and the other representation includes a point cloud and a bounding volume hierarchy, determining presence or absence of penetration of the first and second representations at each point in the point cloud, computing a vector having a magnitude related to depth of the penetration and a direction related to direction of penetration of each penetration, computing at least one force vector corresponding to the full-body contact between the first and second object based on at least one of the penetration vectors.

Shih nowhere discloses or suggests a method of providing haptic feedback corresponding to full-body contact between a first object controlled by an interface device and at least one second object wherein one of the object representations "includes a point cloud and a bounding volume hierarchy," as recited in claim 35. Therefore, claim 35 patentably distinguishes over Shih and is in allowable condition.

Claims 36-42 depend from and further limit claim 35 and are allowable for at least the same reasons.

C.   Claims 10, 43, 47, 52 and 62

Each of independent claims 10, 43, 47, 52 and 62 recite subject matter related to one or more concepts of posture maps, guide zones and niceness factors. As mentioned above, Shih nowhere teaches or suggests any of these concepts. As best as can be understood from the rejection, the Office Action is asserting that since: 1) "Shih teaches tool that are stored in a separate point array of local points intended to represent the tool"; 2) "Shih teaches haptic the [sic] rendering process in terms of location (98), surface (25) and using a path for the tool (28)"; and 3) "Shih teaches a volume storing a density threshold value and points having a threshold value greater or less than the density threshold," the limitations related to generating tool postures, posture maps, guide zones and niceness factors are thus anticipated. Applicant respectfully disagrees. The Office Action attaches incorrect meaning to the teachings of Shih and the subject matter of Applicant's claims.

In particular, with regard to assertion 1), Shih describes a method of optimizing the update of the coordinates of a virtual object at col. 26, line 29 *et seq.* Specifically, Shih describes updating the orientation of the virtual object every hundred iterations and the translation of the virtual object each iteration. The points of the updated virtual object are then stored locally in an array. As clearly stated, Shih is merely describing a standard local update of the location of the virtual object with the recognition that computations may be saved by only updating the orientation every hundred iterations. A simulation of virtual objects necessarily includes a stored representation of the virtual object and updates to the representation to simulate its movement. Claim 10, for example, recites "storing a representation of the tool and a representation of said body." However, this is <u>not</u> the same as storing postures of the virtual object that meet a given criteria. Shih teaches storing an updated version of the <u>representation</u> of the object (i.e., the points that describe virtual object 26), not storing specific desired <u>postures</u> of the object.

Applicant respectfully directs the Examiner's attention to Applicant's specification where in the paragraph beginning at line 20 on page 6 and the paragraph beginning at line 24 of page 17 it describes tool postures and the purpose of providing a posture map of desirable postures. Here the specification clearly describes a posture map as a plurality of postures, each posture describing a position (e.g., an xyz coordinate) and orientation (e.g., rotations about axes of a reference frame) of a tool that result in a desirable proximity relationship between a tool and another body, for

example, a part being machined. It should be appreciated that this is not the representation of the object or an update of the representation, but rather an indication of a transformation required to orient an object such that it has a desired pose. The generated posture map can then later be used to aid in guiding a tool in a desired relationship with, for example, a subsequent part to be machined. Nowhere in Shih are these concepts disclosed or suggested.

With regard to assertion 2), in the paragraph beginning on line 43 of column 10, Shih describes computing tangency planes based on the geometry of the virtual object when "at least one of the points of the virtual tool 28 has penetrated the virtual object 26." That is, the tangency planes are computed only when the tool 28 has made contact with or penetrated virtual object 26. FIGS. 7A-7C further illustrate this point. In particular, query 122 of FIG. 7A illustrates that if no points of the virtual tool penetrate the virtual surface, a tangency plane is never computed (see col. 13, lines 1-13). In fact, a tangency plane cannot be computed because its calculation requires at least one contact point and the geometry of the virtual surface at the at least one contact point. In contrast, a guide zone or snap guide provides the near opposite function of providing a force feedback when an object is not in contact with another body. That is, a guide zone generates a force on the haptic feedback device when a controlled object is within the guide zone but not contacting another body in order to coerce the object toward a body of interest. This concept of providing force to an object to compel it towards or away from a body when it is not in contact with the body is nowhere disclosed or suggested in Shih.

It should be appreciated that posture maps, guide zones, and snap-fit regions include providing force feedback on an object separate from forces that arise out of a collision or contact of the object with another body. This concept in its various forms is entirely missing from the Shih disclosure.

With regard to assertion 3), Shih uses a voxel representation having density values wherein a virtual surface is defined by a threshold density value, that is, the virtual surface is an isosurface of the voxel representation. This simply has nothing to do with niceness factors.

In particular, Applicants respectfully direct the Examiner's attention to the final paragraph on page 12 of the present application where a niceness factor is defined as a measurement of the acceptability and desirability of contact between a portion or feature of a body to which it is

associated and another body. That is, in addition to the geometric representation of the object, predetermined and desirable regions of the tool are labeled with niceness factors to indicate the desirability of having that region of the object contact another object. This concept is nowhere taught or suggested in Shih and particularly not by the standard isosurface description of its virtual object.

Accordingly, Shih is completely silent with respect to generating posture maps, guide zones and/or niceness factors. As such, claims reciting this subject matter patentably distinguish over Shih.

In particular, claim 10 recites a method for generating CAD/CAM postures for a tool operating on a body including storing a representation of the tool and a representation of said body in a computer, using a user controlled haptic interface device to control simulated movement of the tool relative to the body, detecting any collision between the tool and the body for a given posture, including the position on each for each collision, the direction of the collision, and the penetration of the tool into the body, converting the detected direction, point and penetration for each collision into at least one force vector on the tool, summing the force vectors for a given posture, applying said at least one force vector as a corresponding feedback force vector to said interface device, and thus to the user, and storing postures of the tool where the tool collides with the body at a working surface of the tool, but does not otherwise collide with the tool as potential CAD/CAM postures.

Shih nowhere discloses or suggests collision detection including "storing postures of the tool where the tool collides with the body at a working surface of the tool, but does not otherwise collide with the tool as potential CAD/CAM postures," as recited in claim 10. Therefore, claim 10 patentably distinguishes over Shih and is in allowable condition.

Claims 11-25 depend from and further limit claim 10 and are allowable for at least the same reasons.

Claim 43 recites a method of generating a posture map of at least one first object comprising acts of storing a posture of the at least one first object at least at points at which the at least one first object has a posture wherein a portion of at least one geometric region penetrates the at least one static object, and determining the posture being stored based on at least one of a

niceness factor associated with the one or more geometric regions penetrating the at least one static object, and a depth of the penetration of the one or more regions.

Shih nowhere discloses or suggests "storing a posture of the at least one first object at least at points at which the at least one first object has a posture wherein a portion of at least one geometric region penetrates that at least one static object." Nor does Shih disclose or suggest "determining the posture being stored based on at least one of a niceness factor associated with the one or more geometric regions penetrating the at least one static object, and a depth of the penetration of the one or more geometric regions," as further recited in claim 43. Therefore, claim 43 patentably distinguishes over Shih and is in allowable condition.

Claims 44-46 depend from and further limit claim 43 and are allowable for at least the same reasons.

Claim 47 recites a posture map for generating guide paths for at least one first object comprising a set of three-dimensional points in a virtual three-dimensional cartesian space, each three-dimensional point having associated with it a posture. Each posture includes a first, a second, and a third location component representing a reference coordinate location of the at least one first object with respect to a first, a second, and a third axis of the cartesian space, respectively, and a first and a second rotation angle representing a rotation of the at least one first object about the first and second axis, respectively.

Shih nowhere discloses or suggests posture maps at all and indeed not a posture map comprised of "a set of three-dimensional points ... having associated with it a posture," wherein each posture includes "a first, a second, and a third location component ... and a first and a second rotation angle," as recited in claim 47. Therefore, claim 47 patentably distinguishes over Shih and is in allowable condition.

Claims 48-51 depend from and further limit claim 47 and are allowable for at least the same reasons.

Claim 52 recites a method of providing haptic feedback to a user corresponding to simulated movement of a first object in a desired relationship with respect to at least one static object, the simulated movement of the first object controlled by a haptic interface device. The method comprises acts of simulating the movement of the first object in correspondence to

movement of the haptic interface device and providing haptic feedback to the user by providing a correction force to the haptic interface device computed based on at least one of a posture map of the first object and at least one guide zone.

Shih nowhere discloses or suggests "providing a correction force to the haptic interface device computed based on at least one of a posture map of the first object and at least one guide zone," as recited in claim 52. Therefore, claim 52 patentably distinguishes over Shih and is in allowable condition.

Claims 53-61 depend from and further limit claim 52 and are allowable for at least the same reasons.

Claim 62 recites an apparatus for controlling the simulated movement of a first object in a desired relation to at least one second object comprising a haptic interface for controlling simulated movement of the first object, a first representation of the first object stored in memory, at least one second representation of the at least one second object stored in memory, at least one of a posture map and a guide zone to urge the simulated movement of the first object in a desired relationship with the at least one second object.

Shih nowhere discloses or suggests a method for controlling the simulated movement of a first object in relation to a second object using "at least one of a posture map and a guide zone to urge the simulated movement of the first object in a desired relationship with the at least one second object," as recited in claim 62. Therefore, claim 62 patentably distinguishes over Shih and is in allowable condition.

Claims 63-66 depend from and further limit claim 62 and are allowable for at least the same reasons.

CONCLUSION

In view of the foregoing amendments and remarks, this application should now be in condition for allowance. A notice to this effect is respectfully requested. If the Examiner believes, after these amendment and remarks, that the application is not in condition for allowance, the Examiner is requested to call the Applicants' attorney at the telephone number listed below.

If this response is not considered timely filed and if a request for an extension of time is otherwise absent, Applicants hereby request any necessary extension of time. If there is a fee occasioned by this response, including an extension fee that is not covered by an enclosed check, please charge any deficiency to Deposit Account No. 23/2825.

Respectfully submitted

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MARKED-UP CLAIMS

1.   (Twice Amended) A method for controlling the simulated interfacing of a first body controlled by a user with a second body, while providing haptic feedback to the user on such interfacing including:

storing selected representations of said first body and of said second body in a processing apparatus, the representation for one of said bodies [being] including an implicit representation and a binary space partition tree and the representation for the other body being a discrete representation;

using a user controlled interface device to control simulated movement of the first body relative to the second body;

detecting any collision between the first body and the second body, including the position on each body of each collision, the direction of the collision, and force for the collision;

converting the detected direction, point and force for each collision into at least one force vector on the first body; and

applying said at least one force vector as a corresponding feedback force vector to said interface device, and thus to the user.

26.   ·(Twice Amended) A system for controlling the simulated interfacing of a first body controlled by a user with a second body, while providing haptic feedback to the user on such interface including:

at least one memory storing selected representations of said first body and of said second body, the representation for one of said bodies [being] including an implicit representation and a binary space partition tree and the representation for the other body being a discrete representation;

a user controlled hepatic interface device; and

processing apparatus responsive to said interface device for providing simulated movement of the first body relative to the second body, said processing apparatus detecting collisions between the bodies resulting from such simulated movement, including the position on each body of each collision, the direction of the collision, and force for the collision, converting

the detected direction, point and force for each collision into at least one force vector and, feeding back the at least one force vector through said interface device.

35.   (Amended) A method of providing haptic feedback corresponding to full-body contact between a first object controlled by an interface device and at least one second object, the method comprising acts of:

storing a first three dimensional representation and a second three dimensional representation of the first object and the at least one second objects, respectively, wherein one of the representations includes at least one region defined by a implicit equation and the other representation includes a point cloud and a bounding volume hierarchy;[.]

determining presence or absence of penetration of the first and second representations at each point in the point cloud;

computing a vector having a magnitude related to depth of the penetration and a direction related to direction of penetration of each penetration;

computing at least one force vector corresponding to the full-body contact between the first and second object based on at least one of the penetration vectors.

36.   (Amended) The method of claim 35, [wherein the act of forming the point cloud representation includes an act of forming a bounding volume hierarchy of the point cloud representation and] wherein the act of determining a presence or an absence of a penetration includes an act of traversing the bounding volume hierarchy, each successive determination of a presence or an absence of a penetration involving portions of the bounding volume for which the presence of a penetration was determined.

43.   (Amended) In a virtual three-dimensional environment including a haptic interface device to control a simulated movement of at least one first object with at least five degrees of freedom with respect to at least one static object, the at least one first object represented by one or more geometric regions, a method of generating a posture map of the at least one first [moveable] object, the method comprising acts of:

storing a posture of the at least one first [moveable] object at least at points at which the at least one first object has a posture wherein a portion of at least one geometric region penetrates the at least one static object; and

determining the posture being stored based on at least one of a niceness factor associated with the one or more <u>geometric</u> regions penetrating the at least one static object, and a depth of the penetration of the one or more <u>geometric</u> regions.